LCA in Japan

Analysis of the Potential for a Comprehensive Approach Towards LCA and EMS in Japan

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Abstract

Sustainable development can only be achieved if industry adopts *both* product related and organisation related environmental management tools, such as Life Cycle Assessment (LCA) and Environmental Management Systems (EMS). In Japan, EMS (ISO 14001) is more widely applied than LCA (ISO 14040). Therefore, *one* means by which Japanese industries could be motivated to adopt and use LCA is to relate LCA-activities to the policies and instruments of ISO 14001. The potential of such a comprehensive approach was analysed by a survey of 270 Japanese enterprises (response rate 45%). The results indicate that 19% of the responding representatives had responsibilities for both LCA and EMS, while the remaining only work in one of both fields. A statement in the company's/ plant's Environmental Policy of ISO 14001, stating that LCA is to be used as part of the EMS, was found in 42% of all companies. A surprising number (39%) either already use, or plan to use, LCA and EMS as combinated/integrated tools. A strong argument for the establishment of a comprehensive approach can be seen in the perception of the usefulness of LCA, which was rated significantly higher in companies that acknowledged the complementary potential of LCA and EMS.

Keywords: EMS; Environmental Management; ISO 14001; ISO 14040; Japan; LCA; Life Cycle Assessment

1 Introduction

Among the various well-known issues of interest for research and application of LCA, two topics have recently gained increasing attention: LCA in Japan and developments aiming at a comprehensive approach towards product and organisation related environmental management tools, i.e. Life Cycle Assessment [1] and Environmental Management Systems (EMS) [2-5]. Both LCA in Japan [6-8] as well as interfaces of LCA and EMS [9,10] have been addressed by several articles in this journal, most recently by Hunkeler et al. [11] respectively Finkbeiner et al. [12].

According to Hunkeler et al., LCA was formally recognised in Japan with the creation of the industry sponsored Japan LCA Forum in 1991, though early assessments were carried out as early as the mid 1980s. The growth of LCA activities in Japan is indicated, for example, by the currently more than 130 users of the NIRE-LCA-software [13]. In addition, further promotion of LCA can be expected from the ambitious National LCA-Database project sponsored by the Ministry of International Trade and Industry (MITI) and organised by the Japan Environmental Association for Industry (JEMAI). However, despite these activities and efforts to study and deal with LCA, the actual application to assist decision-making within companies is still in its infancy. Therefore, it is still a task to motivate and facilitate incorporation of LCA into the business activities from planning and design to production and marketing.

With regard to the second topic of this paper – comprehensive approach to LCA and EMS –, Finkbeiner et al. concluded that both LCA (ISO 14040) and EMS (ISO 14001) are valuable tools for improving the environmental performance of organisations. Due to the company oriented, procedural approach of EMS and the product oriented, analytical concept of LCA, they are methodologically not compatible, even if at first sight similar system elements like the input/output-analysis of material and energy flows are compared. The integration of the analytical EMS element Corporate Ecobalance (CEB) into LCA might be theoretically possible, though practical relevance is questionable due to different system boundaries, different reference units, parameters and data. A promising solution might be a company/situation dependent combination of LCA and EMS.

This paper analyses and relates these two subjects due to the unique situation and large potential for establishing a comprehensive approach in Japan. This expectation is based on the fact that Japan is the worldwide leader in terms of the

absolute number of ISO 14001 certified companies [14] and that LCA is at the very beginning of being recognised as a powerful tool to assist corporate governance. Therefore, both LCA and EMS could benefit from each other: LCA could assist the currently more than 1500 Japanese companies respectively plants certified according to ISO 14001 in their main task to maintain the implemented management system and actually achieving continual improvement, while the acceptance and influence of LCA could be promoted by relating it to the policies and instruments of ISO 14001.

To analyse the current situation and assess the future potential concerning LCA and EMS in the Japanese industries, a questionnaire was designed and evaluated. The procedure, representativity, results and conclusions will be discussed in the following sections.

2 Method

For acquiring the necessary information from Japanese companies, a questionnaire was used (*see* Appendix A, *p. 132*). The chosen sample consisted of 270 companies and comprised two groups, an LCA-group and an EMS-group. The initial LCA-group of 100 companies was chosen from the NIRE-LCA-software user list. The initial EMS-group of 170 companies respectively plants was randomly picked from several branch specific lists of certified companies.

A representative sampling procedure for the **LCA-group** was not critical, since NIRE is aware of the relevant background of these companies and the NIRE-software users can be assumed to represent the total population of LCA-active Japanese companies fairly well.

With regard to the **EMS-group**, the sampling procedure was more critical. According to an analysis of the branch distribution of certified Japanese companies relating to the middle of 1997, more than 50% belonged to the electrical or electronic industries followed by the general machinery and the chemical industry [14].

However, for the purpose of this investigation it seemed more appropriate to strive for a broad sample covering as many different industries as possible rather than representing the actual branch distribution. The existence of branch-specific listings of certified companies helped to obtain a diverse industry range (*see* Result section).

As mentioned above, this procedure was used to define the initial groups rather than the final LCA or EMS-group. The reason was that, according to some answers to the questionnaire which were used to characterise the sample, company or responding person, it was revealed that some respondents actually belonged to the EMS-group even though they were from the initial LCA-list and vice versa. The criteria chosen to assign individual answers to the groups were the **main responsibility** and the **amount of time** spent for each of the tools. However, the initial and final groups agreed by more than 95%.

A total of 121 questionnaires were returned which equals an overall response rate of 45% (LCA-group: 41%; EMS-group: 47%). Due to the fact that six of the returned questionnaires contained only limited, unclear or contradictory information, they were excluded from the sample (115 questionnaires) used for the following evaluations.

3 Results

In order to relate to the full and therefore most representative sample size, the results discussed in the following section remain on the **first level** of evaluation, i.e. they were obtained by analysing question by question. Second-level evaluations which assess interdepencies between the answers to different questions or subdivide the sample into further groups, are only reported in Figure 4.

3.1 Characterisation of the sample

A total of 91% of the companies (LCA-group: 85%; EMS-group: 95%) identified themselves in the voluntary question concerning the company name, while the remainder chose to be anonymous. With regard to the distribution of the industry branches to which the responding companies belonged, the goal to cover a large number of different branches was achieved. Most answers of the EMS-group came from the electronic/electrical as well as the chemical and industrial machinery branches. The sample underestimates the actual dominance of the electronic/electrical industry, though apart from that represents the main groups quite well. This result is in line with the chosen sampling procedure which aimed at a broad representation of industries. The branch distribution within the LCA-group was even more homogenous with higher fractions in the power generation, steel, architecture, business machine and automobile sectors.

Figure 1 indicates the sample distribution of companies in terms of employees. The main result was that EMS is widely used by all sizes of companies, while LCA is mainly applied by larger companies. More than 75% of all companies in the EMS-group had less than 10,000 employees, while almost 50% of the LCA-active companies had more than 10,000 employees. In the LCA-group, there is a steady increase from small to large companies, while the EMS-group has a maximum in the range of 1001 to 10,000 employees. In the companies with less than 1000 employees, a fair number maintain an EMS, while LCA is only applied by relatively a few firms.

A chi-square test (*see* Appendix B, *p. 132*) was performed to assess the statistical significance of this finding. To obtain at least five sample values, four intervals were used (companies with less than 500, 501 to 1000, 1001 to 10,000 and over 10,000 employees). The deviation between the LCA-group and the EMS-group was $\chi_0^2 = 18{,}31$. For three degrees of freedom and a significance level $a = 0{,}001$, the solution of the chi-square distribution is $c = 16{,}27$, i.e. the

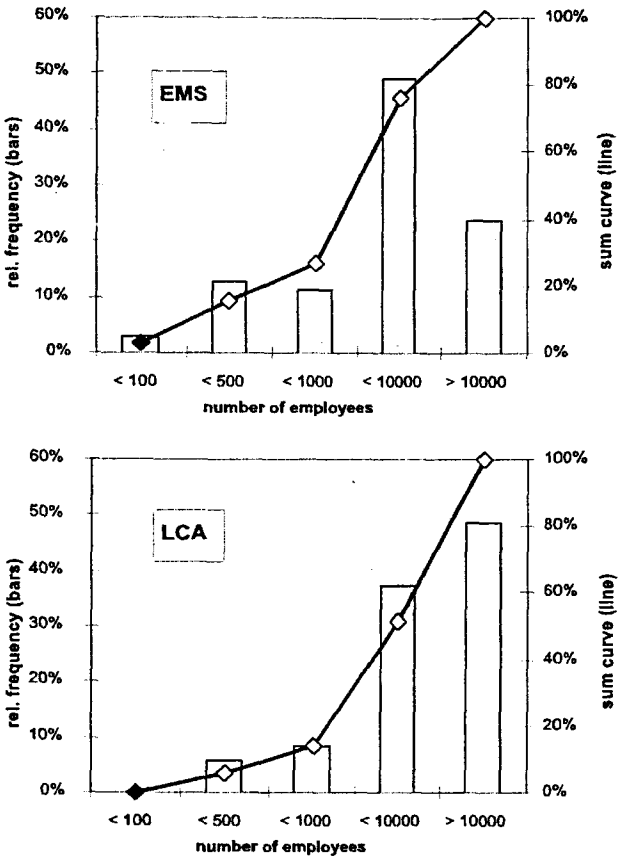

Fig. 1: Distribution of company size measured by the number of employees in the EMS and LCA-group (bars show the relative frequency, lines show the sum curve)

observed difference between the LCA and the EMS-group has a statistical significance of more than 99,9%.

This result indicates one of the main problems of LCA, i.e. to reach small and medium sized enterprises. Because this group of companies is, however, quite active in EMS, the result actually shows the potential for a comprehensive approach. To relate LCA to EMS could be a promising way for LCA to reach small and medium-sized companies.

Apart from the characterisation of the sample with regard to the companies some questions were used to characterise the responding representatives. It was found that, as expected, most representatives (81%) were responsible for only one of the tools. However, the 19% responsible for both tools are encouraging with regard to our suggested combination approach, since these companies obviously already acknowledge the importance to tackle both fields in a comprehensive way by considering it in their organisational structure.

Another question asked how much time the individuals spend for either one or both of the tools. In comparison to the results concerning the organisational responsibilities, the answers to this question revealed rather an interesting result: more employees spent time on both tools than had organisational responsibilities. In other words, a fair amount of the staff of Japanese companies who are responsible for only one of the tools, actually spends time to study the other tool even though it is outside their direct duties. This leads to the conclusion that they acknowledge the importance to have a certain understanding of both tools, even if one's responsibilities are restricted to only one. This result is encouraging in the light of the hypothesis and conclusion of Finkbeiner et al. that environmental managers within companies should have know-how about both tools [6]. From a management point of view, this suggests that the structural organisation might be adapted to this operational requirement.

3.2 Analysis concerning EMS and LCA

To analyse the current situation concerning a comprehensive approach towards EMS and LCA, two main indicators are reported. First, the existence of statements in the Environmental Policy of ISO 14001 saying that LCA is to be used as part of the EMS. Second, a self assessment of the companies whether they use or plan to use LCA and EMS as either combined or separate tools.

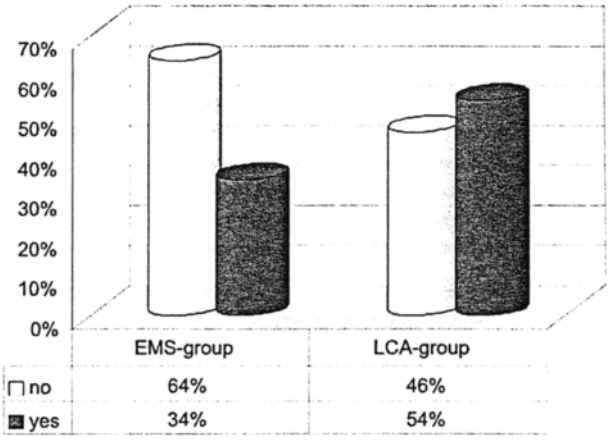

Fig. 2: Existence of an LCA-related statement in the Environmental Policy according to ISO 14001

Figure 2 shows the percentage of companies in the respective groups that have a statement in the company's/plant's Environmental Policy of ISO 14001 saying that LCA is to be used as part of the EMS. It is revealed that 34% of the EMS-group and even 54% of the LCA-group (overall result of the combined sample is 42%) had such a paragraph in their policy. This result indicates that many companies already acknowledge the positive element which LCA can add to complement their EMS.

It is striking that more than the half of all companies in the LCA-group had such a statement. Depending on the temporal sequence of implementig LCA- and EMS-activities this result can be interpreted in two ways. If companies implemented an EMS before using LCA it follows that many cur-

rent LCA-activities may have been triggered by the introduction of Envionmental Management systems. If companies already had LCA-activities before implementing an EMS, many of them obviously decided to incorporate LCA in their EMS-frameworks.

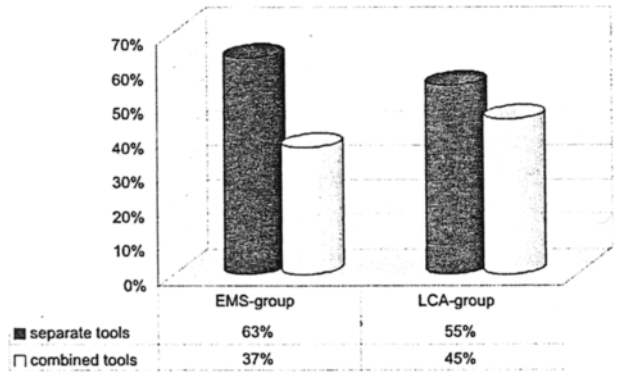

Fig. 3: Distribution of the actual/planned use of LCA and EMS as separate or combined tools

Figure 3 shows the percentage of companies that according to their perception already use or plan to use LCA and EMS as combined/ integrated tools. The results indicate that 37% of the EMS-group and 45% of the LCA-group (overall result of the combined sample is 39%) already use or will use LCA and EMS as combinated/ integrated tools. Again, there is a surprisingly large fraction of companies that already acknowlegde the potential of a comprehensive approach to both tools. The distribution between the LCA and EMS-groups is even more homogenuous compared with the presence of a environmental policy statement (*compare* Fig. 2).

Another question was used to evaluate how both groups estimated the usefulness and importance of LCA and EMS respectively. Overall, both tools were seen by more than 60% of both groups as useful or very useful. Only 3% of the EMS-group think that LCA is not useful. An interesting difference between the LCA and the EMS-group is that the EMS-group rates their "own" tool significantly more useful than the other, while the differences in the profiles of the LCA-group are smaller. More than 50% of the EMS-group think that EMS is very useful, while the respective estimation of LCA by the LCA-group is only about 20%.

To assess the potential of a comprehensive approach towards EMS and LCA, the answers to this question were analysed further by separating the EMS-group according to the existence or non-existence of an LCA-related ISO 14001 policy statement and according to the use of LCA and EMS as separate respectively combined tools.

Figure 4 shows how the EMS-group estimates the usefulness of LCA depending on the existence of a statement in the company's/plant's Environmental Policy of ISO 14001 saying that LCA is to be used as part of the EMS respectively the actual use or planned use of LCA as an element within EMS. It is obvious and striking that the perceived usefulness of LCA is significantly larger in companies that have a LCA-related environmental policy statement and regard LCA and EMS as dependent and complementary tools.

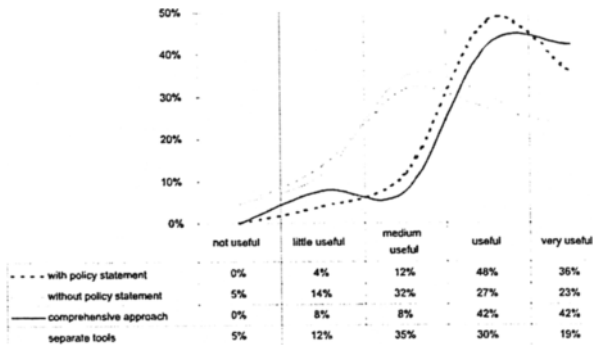

Fig. 4: Estimation of the usefulness of LCA in dependence of the (non-)existence of a LCA-related ISO 14001 policy statement and use of LCA and EMS as separate or combined tools

Again, chi-square tests (*see* Appendix B, *p.* #) were performed to assess the statistical significance of these findings. The five discrete ratings of question III.10 in Appendix A were used as intervals. The deviation between the groups with and without policy statement was $\chi_0^2 = 11{,}8$. The deviation between the groups that use or plan to use LCA and EMS as combined tools respectively separate tools was $\chi_0^2 = 16{,}2$. For four degrees of freedom and significance levels $\alpha = 0{,}025$ (0,005), the solution of the chi-square distribution is $c = 11{,}14$ (14,86). As a conclusion, the observed difference due to the policy statement has a statistical significance of more than 97,5%, while the difference due to the separate respectively combined use of LCA and EMS is more than 99,5%.

This result is a strong argument that LCA practitioners should work for the development of a comprehensive approach; in the eyes of the companies, this obviously increases the usefulness and importance of LCA.

4 Discussion

The results reported in this paper represent a "snap-shot" of the situation in the Japanese industries during summer 1998. The interpretation has been restricted to some key findings and no comprehensive statistical analysis is reported to reflect the "snap-shot" character of questionnaires in order to avoid an interpretation that goes beyond the quantity and quality of the underlying data sample.

Because the authors are not aware of any publication with similar investigations in other parts of the world, a quantitative comparison of the results for Japan with other countries is currently not possible. In qualitative terms, the authors' experience in European countries, especially Germany, implies that a comprehensive approach to LCA and EMS is currently not on the agenda of most companies. Usually, different departments are responsible for LCA and EMS-activities.

With regard to the United States, a major difference to Europe and Japan is the widely reserved or even reluctant attitude to implement a certified EMS. As of December 1998, only 210 U.S. companies had obtained certification according to ISO 14001. This is less than in countries such as Switzerland (292), Taiwan (398) or Korea (463) and far behind Japan (1542) and Germany (1100 plus 1795 registrations according to the European EMAS scheme) [15]. Therefore, a similar investigation in the United States might come too early.

The basic hypothesis of our study is that sustainable development can only be achieved if industry is adopting *both* product-related and organisation-related environmental management tools, e.g. LCA and EMS. Because ISO 14001 is more widely applied than LCA in Japan, one important strategy to motivate Japanese industries to adopt and use LCA is to relate LCA activities to the policies and instruments of ISO 14001. The analysis of the potential of this strategy revealed several encouraging results, as was described above. Therefore, it seems that companies actually require methodologies and procedures to achieve the goal of establishing a sound and comprehensive Life Cycle Management approach. Scientific work on this topic has just begun. However, there is a strong need to supplement industries with that kind of information, which means that the scientific community should address this topic in the future.

Due to the complexity and diversity of companies and products in a global economy, it is most likely that there will be no single solution or approach to tackle this task. The decision of how the tools should be applied depends on the individual situation of the company and the main environmental problems of the company. Therefore, this decision has to be made company by company. However, in general it might be advisable for a company with a wide product spectrum to integrate LCA-elements into their EMS, while companies with fewer products or single products with a high environmental relevance might stress LCA supplemented by EMS-elements.

From a cost/benefit-perspective, this combination approach seems most effective because it concentrates on and permits individual solutions. A framework of how LCA-elements can serve as tools to fulfill the goals of an EMS, will be presented elsewhere [16]. This might be an important application of LCA in the future because it assists the maintenance of EMS. After implementing an EMS, first improvements are usually realised with moderate efforts on a general organisation level, e.g. by Corporate Ecobalances because no systematic procedure has been in place before. However, after this straightforward improvement, it gets increasingly difficult for companies to identify further improvement potentials. Therefore, additional tools are needed to measure, achieve and maintain the continual improvement promised by EMS. One of the tools which has the potential to fill this gap is LCA. LCA as a more detailed and technically oriented assessment tool can help to broaden the EMS perspective by the life cycle and system view. As a consequence, optimisation potentials that go beyond the scope of a Corporate Ecobalance can be revealed and quantified.

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Appendix A

As requested by one of the referees, the questionnaire used for this paper is documented here. It should be noted that only the eight questions evaluated for this paper are documented, not the complete questionnaire consisting of a total of 21 questions.

I. Questions about the company/ plant

1. Name of the company, plant and division: (voluntary answer)_____
2. To which Industry Association does the company or plant belong?

O Electric Power	O Gas	O Petroleum
O Iron & Steel	O Aluminium	O Chemical
O Cement	O Paper	O Automobile
O Electrical	O Electronic	O Architecture
O Industrial Machinery	O Business Machine	O other, _____

3. Approximate number of employees at the company: _____ plant: _____

II. Questions about the responding person

1. Are you responsible for
   O Life Cycle Assessment (LCA) O both LCA and EMS
   O Environmental Management System (EMS, ISO 14001) O other, _____
2. If you are responsible for LCA, EMS or both about how many percent of your total work time do you approximately spend for these topics? for LCA: _____ % for EMS: _____ %

III. Questions relating to LCA and EMS-activities

8. Do you have a statement in your company's/ plant's Environmental Policy of ISO 14001 that says that LCA is or will be used as part of the EMS? O yes O no
9. Does your company/ plant use or plan to LCA and EMS in an combined or integrated way or are they used as two separate tools?
   O as combined/ integrated tools O as separate tools
10. How useful/ important do you think are LCA and EMS on a scale from 1 to 5?
    (Please indicate a rating: 1 = not useful/ important; 2 = little useful/ important; 3 = medium useful/ important; 4 = useful/ important; 5 = very useful/ important) LCA: _____ EMS: _____

Appendix B

Chi-square is a frequently used test of significance in the social and natural sciences [17]. It is based on the null hypothesis: the assumption that there is not a relationship between the variables investigated. The chi-square test [18] is a basic randomness test which is part of a series of numerous other tests. It can be found in the literature, in tables for chi-square probability as well as in mathematical formulae for computing these probabilities.

If a chi-square test is used for a continuous distribution, the x-axis of the probability distribution has to be divided in K intervals I_1, I_2, ...I_K ensuring that each interval contains at least 5 sample values x_1, x_2,...x_n. For discrete distributions, the sample values for each event can be used. From F(x) the probability p_i that the stochastic variable X gets a certain value within I_i can be calculated. From that the number of theoretically expected sample values in I_i can be derived:

$$e_i = np_i \tag{1}$$

With e_i and the measured sample values b_i the deviation c_0^2 is calculated as follows:

$$\chi_0^2 = \sum_{i=1}^{K} \frac{(b_i - e_i)^2}{e_i} \tag{2}$$

The deviation c_0^2 can now be compared with values of the chi-square distribution. For a chosen significance level a (typically 5% or 1%) and K – 1 degrees of freedom, the solution c of equation (3) can be computed or obtained from statistical tables.

$$P(\chi^2 \le c) = 1 - \alpha \tag{3}$$

In this paper, we used the chi-square test to evaluate the statistical significance of three hypotheses:

Hypothesis 1: The size distribution of companies applying LCA respectively EMS is different, i.e. LCA is mainly applied by large companies while EMS is applied by all sizes of companies.

Hypothesis 2: The usefulness of LCA is rated higher in companies having a statement in the Environmental Policy of ISO 14001 stating that LCA is to be used as part of the EMS.

Hypothesis 3: The usefulness of LCA is rated higher in companies using or planning to use LCA and EMS as combined or integrated tools.

Therefore, the results of the respective questions were grouped according to each hypothesis and the deviation χ_0^2 was calculated. A statistically significant difference between the groups supporting our hypotheses is obtained if $\chi_0^2 > c$. The results are reported in the main text.